



Morning Session is Currently in Progress

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Electrified Transportation – on the Road to V2B & V2G

Moderator: **Commissioner Janea A. Scott**

Presenters: **Anthony Harrison, Dr. Tim Lipman, Dr. Sunil Chhaya, Alissa Harrington**





Electrified Transportation Panel Questions

1. Investments in infrastructure are being made now and charging infrastructure is being deployed now. When do we need to implement these VGI solutions? Are there any "no regrets" actions that we should collectively be taking now, even as some of the VGI questions are being researched?



Electrified Transportation Panel Questions

2. What are the critical technical barriers to V2G and V2B adoption from your industry perspective?
 - a. Communication, cybersecurity, submetering, etc.?
 - b. What can be learned from smart charging and DR that can be applied to V2G and V2B?
3. What policies are needed to encourage standardization in VGI programs to enable V2G and V2B?



Electrified Transportation

Panel Questions

4. What VGI technology advancements and strategies are needed to maximize the value and benefits of V2G and V2B?
 - a. Examples, but not limited to: advanced communications, wireless and high-power charging, fault detection and diagnostics, etc.
 - b. How is an ecosystem of manufacturers forming to ensure global interoperability, where in concept any EV could plug into any charger and discharge, if such stored energy was needed?
 - c. Which V2G/V2B use cases would most benefit from pilot demonstrations?



Electrified Transportation Panel Questions

5. What strategies can be used to maximize V2G and V2B benefits for EV battery health?
 - a. What is needed to better understand the relationship between battery life, vehicle range, and V2B/V2G operation? What research is needed to better assessing and preserving battery life in V2B and V2G scenarios?
 - b. What new human machine interfaces are needed to reflect customer preferences, curiosities, or concerns about V2G energy exchanges?



California
Energy Commission
Research & Development

Vehicle to Grid and Vehicle to Building Technologies

Actions, Barriers, Strategies, Optimal Battery Use
Energy Research and Development Division

Sunil M. Chhaya, PhD – Technical Executive, EPRI
02/19/2019





When to Implement VGI? List of No-Regret Actions Now

1. Ensure Infrastructure Deployment is done in a 'Future-Proof' way *vis-à-vis*
 1. Electrical System and DER Integration / Interconnection
 2. Communications Standards / Protocols
 3. Value-Creating Use Cases Prioritized for Implementation
 4. Integration of EVs as a Resource Class within DRP and IRP/LTPP



Critical Technical Barriers and *Policy-Informing* TD&D Needs

2. What are the critical technical barriers to V2G and V2B adoption from your industry perspective?
 - a. Communications – **Forward / Backward compatibility to allow both retrofit and forward-looking implementations - Must factor in prevailing best practices and installed base**
 - b. Communication, cybersecurity, submetering, etc.? - **New protocols need to be consistent across all DER classes (PV, EV, Storage, EE/DR etc) for flexibility in EV integration across Buildings, microgrids and residential premises – PV, EV and Storage should all be treated as smart inverters with unique constraints**
 - c. What can be learned from smart charging and DR that can be applied to V2G and V2B? – **A clear understanding of value leading to incentive programs and ease of customer engagement**
3. What policies are needed to encourage standardization in VGI programs to enable V2G and V2B? – EPRI cannot comment on Policy but **scaled-up pilots implementing a variety of V2G/V2B/V2Microgrid (resiliency) use cases will inform on technology, value and planning aspects**



VGI technology advancements and strategies needed to maximize V2G/V2B value and benefits

1. Light Duty –
 - a. Uniform approach to DER integration: PEVs, PV and Storage treated as smart inverters
 - b. Greater emphasis on incorporating BTM V2G as a residential storage mandate compliance pathway
 - c. Stimulate scale-up of on- and off-vehicle V2G and V2B power electronics which is durable, low-cost, high-efficiency and open standards-based
 - d. V2G on- and off-vehicle inverter interconnection Requirements to be uniform across all DER classes, defined state-wide (similar to Rule 21 for smart inverters)
2. Interoperability within the Ecosystem – only assured through open standards-based implementation
 - a. 14-086 a first step in this direction: Honda and FCA vehicles interoperated across open standards-based EVSEs
 - b. Which V2G/V2B use cases would most benefit from pilot demonstrations?
 - Peak Shaving, PV oversupply balancing, real-time pricing tariff design, ramp-up support and maximum self-consumption



Battery Health and HMI Considerations

1. Strategies for optimal battery health
 - a. Definition of standardized V2G battery test cycle – EPRI DoE VTO-sponsored EE0007792 project with NREL and ORNL defining this
 - b. Ensuring batteries are letting the life-optimized capabilities known to external entities for management / energy services – a parameter within the standards – being tested on EE0007792
 - c. Validate assumption that fast-response regulation services and in general Ancillary Services have limited value with disproportionately larger battery wear – Verified on 14-086
 - d. Validate hypothesis that BEVs with larger batteries will experience minimal battery impact for high-value grid services (see earlier slide) – to be verified on EE0007792
2. HMI – notifications, customer prefs, energy dashboard, monetary benefits, grid conditions, customer opt in/out provisions

An Open-Source, Open-Architecture Software Platform For Plug-In Electric Vehicle Smart Charging In California (XBOS-V)

EPIC Symposium
Sacramento, California
February 19, 2019

Timothy Lipman, PhD
UC Berkeley TSRC Co-Director
LBNL Research Affiliate
telipman@berkeley.edu



UNIVERSITY OF CALIFORNIA *Berkeley*
Transportation Sustainability
RESEARCH CENTER



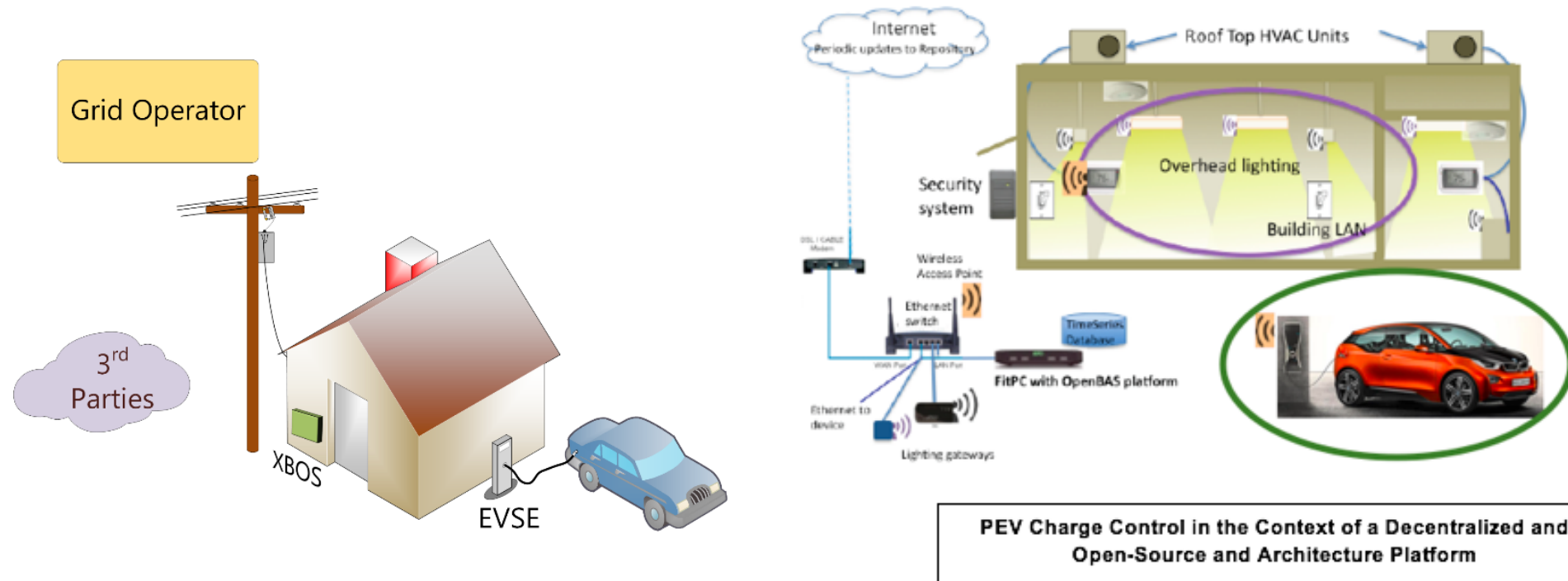
California Energy Commission

EPIC 15-013 Grant – “XBOS-V” Overview

- UC Berkeley’s TSRC, BECI, and ERG units with BMW
- \$1.59M grant over three years, awarded April 2016 under PON 14-310
- Key idea is to aggregate local loads including EV charging for streamlined grid communication using readily extensible, open code and architecture built on low-cost computing platforms
- Project also includes analysis of distribution system and larger grid benefits, and assessment of learnings from BMW “ChargeForward” pilot with PG&E

XBOS-V Project – VGI Through Site-Level Building Control Systems

EXtensible Bilding Operating System (XBOS) for
Single Point of Grid Interface and Coordinated Control of Local Building Loads



XBOS-V Project – Task Overview

UC Berkeley XBOS-V Project – Cyber-Physical Space

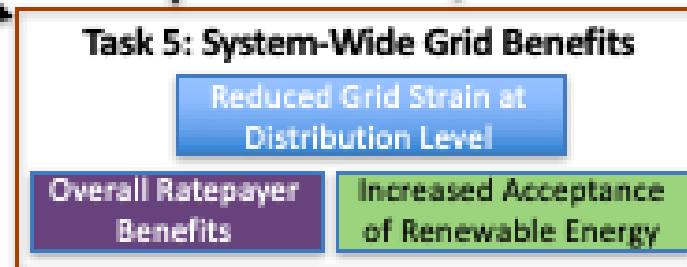
Cyberspace



Physical Space



Policy Environment

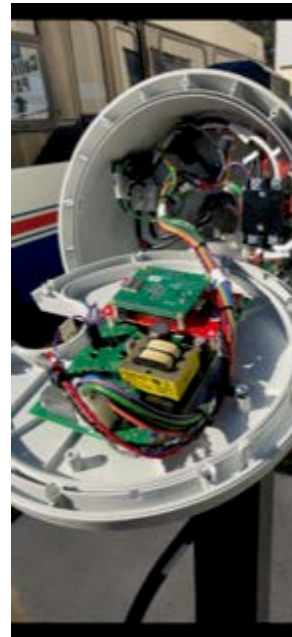


XBOS-V: Technical Task Overview

- Task 2 – User Needs Assessment
 - Focus Groups with BMW ChargeForward Program Participants (n=50)
 - Building Energy Manager Interviews (n=12)
- Task 3 – XBOS-V Module Development
 - Develop open-source XBOS-V software code based on XBOS platform to communicate with EV chargers for load control
 - Create physical VGI testbed to develop and test “XBOS-V” module
 - Validate code using UC Berkeley BGC (Level 2) and residential (Level 1) testbeds
- Task 4 – Assess Distribution-Level Benefits of VGI
 - Understand system power quality issues and VGI potential
 - Develop algorithms for congestion relief/voltage stability through smart charging
- Task 5 – Study Overall Grid and Ratepayer Benefits
 - Understand potential larger grid impacts and benefits, and EV driver and ratepayer \$ return mechanisms
 - SWITCH and PLEXOS modeling of CA grid and potential VGI resource for 2024-2030

Task 3 – VGI Test Bed at Berkeley Global Campus

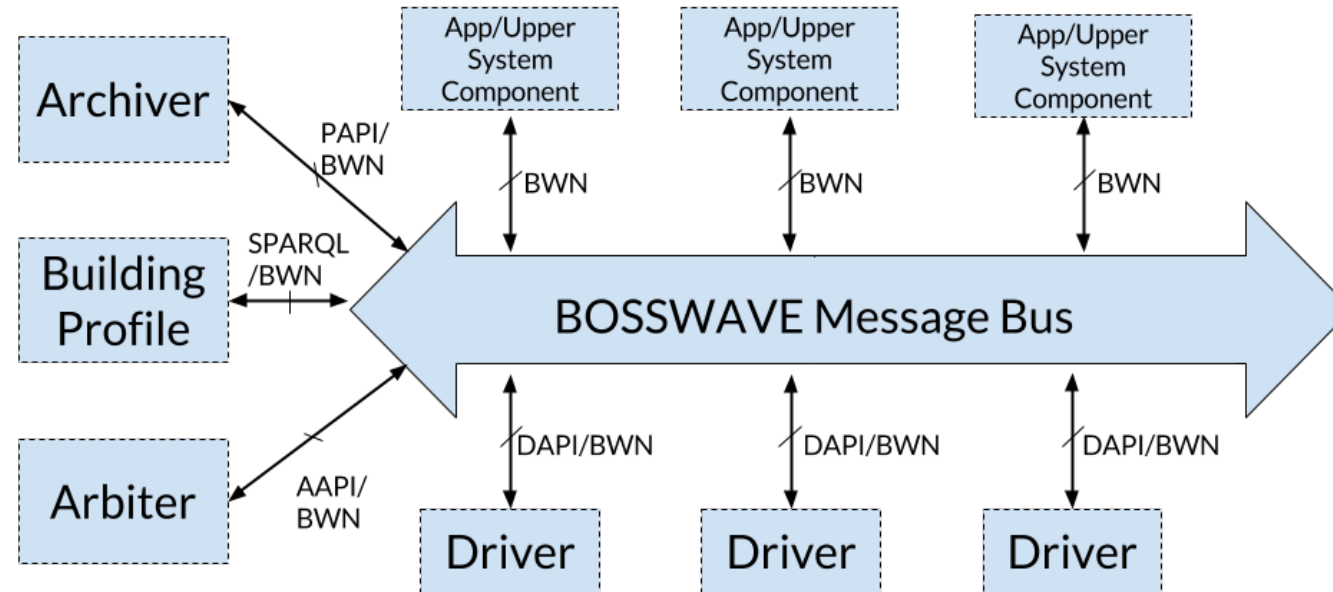
- VGI Testbed combines a Wi-Fi capable charger, a sophisticated NHR power system control and visualization device, open-source software code, and remote telemetry



Model 9410 single Power Module front panel view

Task 3 - UC Berkeley XBOS Platform

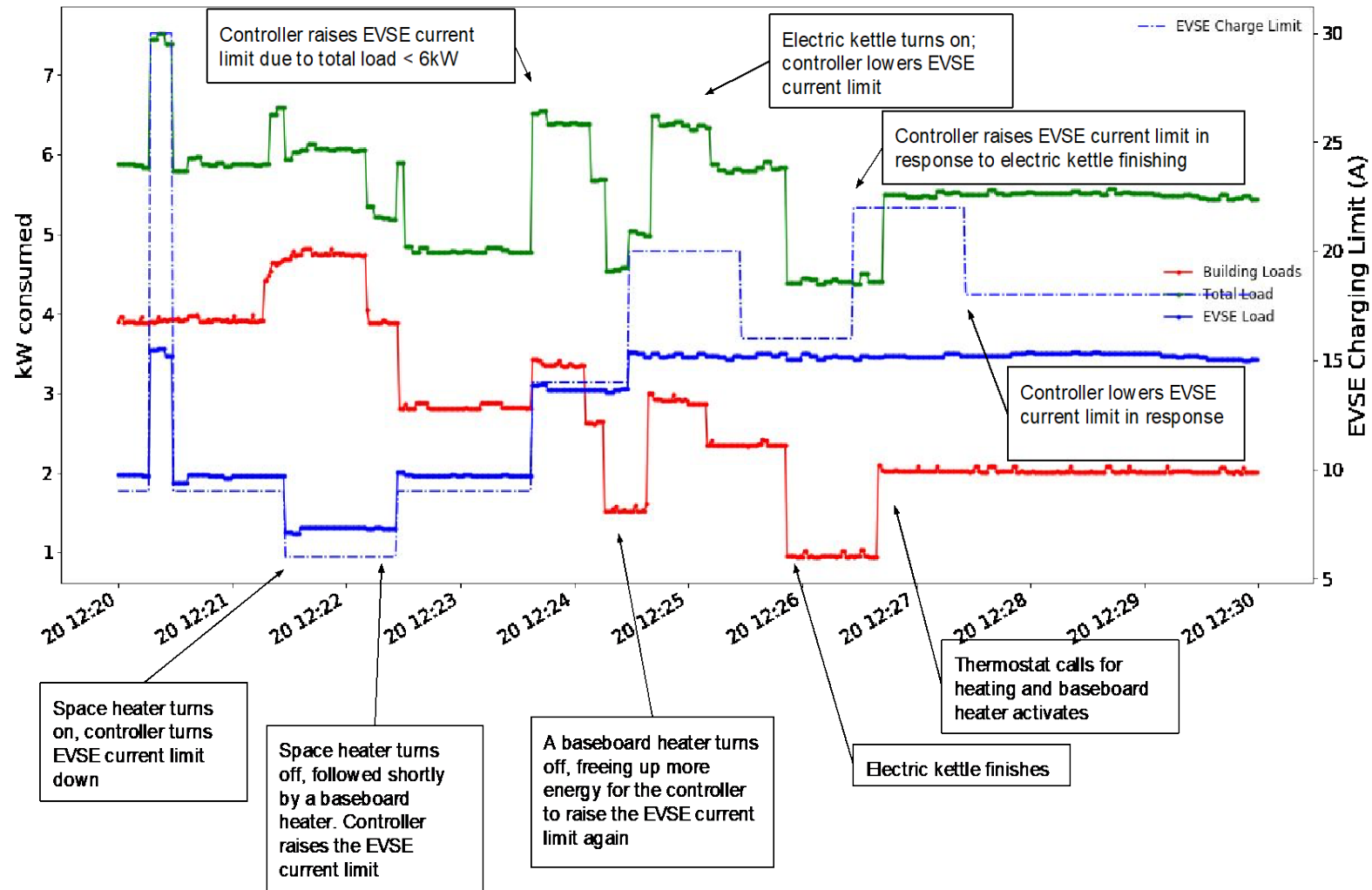
- XBOS = EXensible Building Operating System



DAPI: Driver API
AAPI: Arbiter API
SPARQL: RDF query language
PAPI: Pundat API

PAPI: Pundat API
BWN: BOSSWAVE Native Protocol
(over TCP/IP)

Task 3 – Coordinated Load Control Including EVSE Using XBOS-V at Berkeley Global Campus



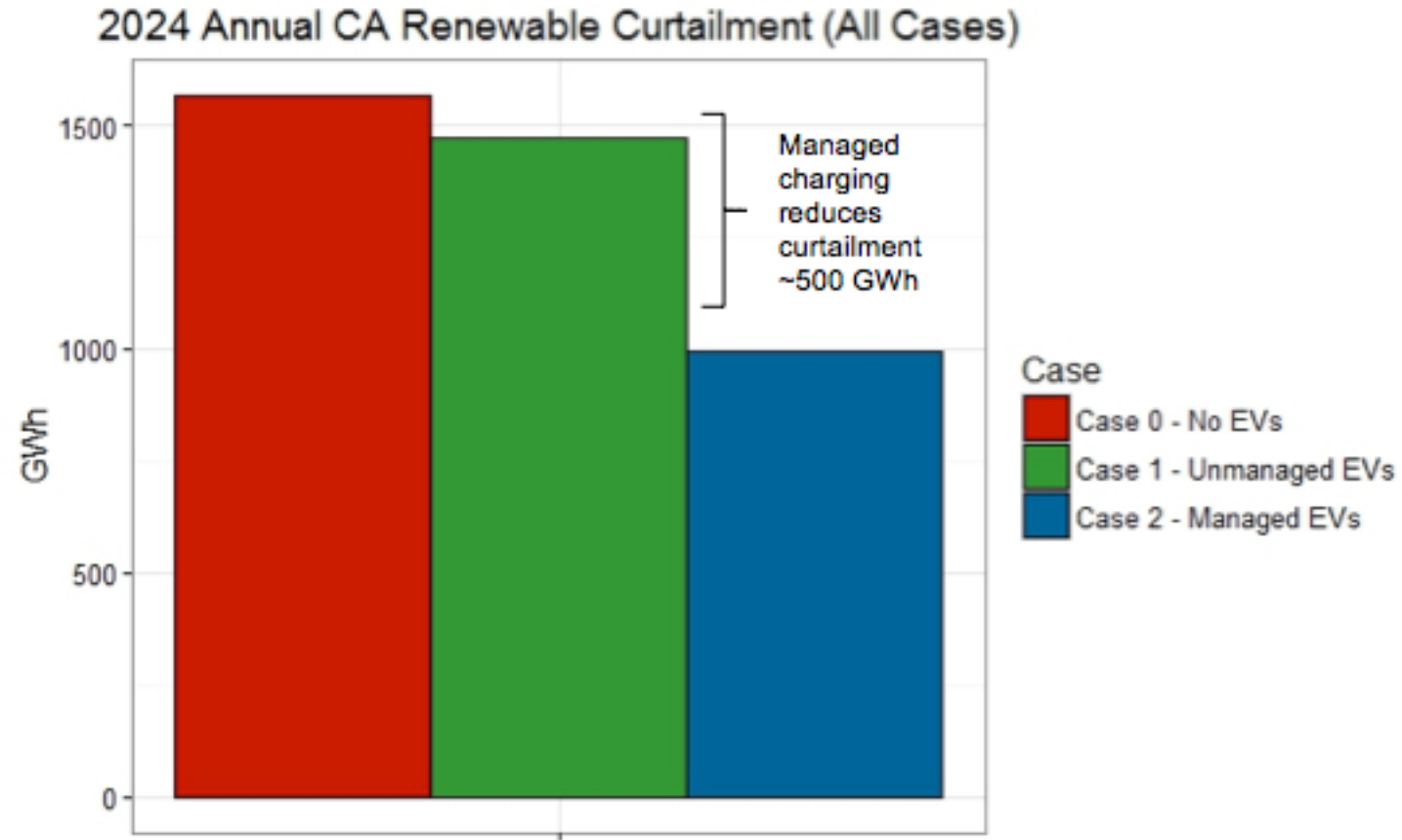
Summary of Task 3 Accomplishments

- Created VGI testbed with installation of XBOS system for coordinated load control at Berkeley Global Campus
- Instrumented building at BGC with Wi-Fi based load controllers (baseboard heaters, lighting, and plug loads)
- Developed, tested, and de-bugged open-source device drivers for control of Level 1 and Level 2 EVSE
- Initial implementation using OCPP 2.0 protocol as extension concept
- Release of code and documentation through Github

Task 5 – Grid and Ratepayer Benefits

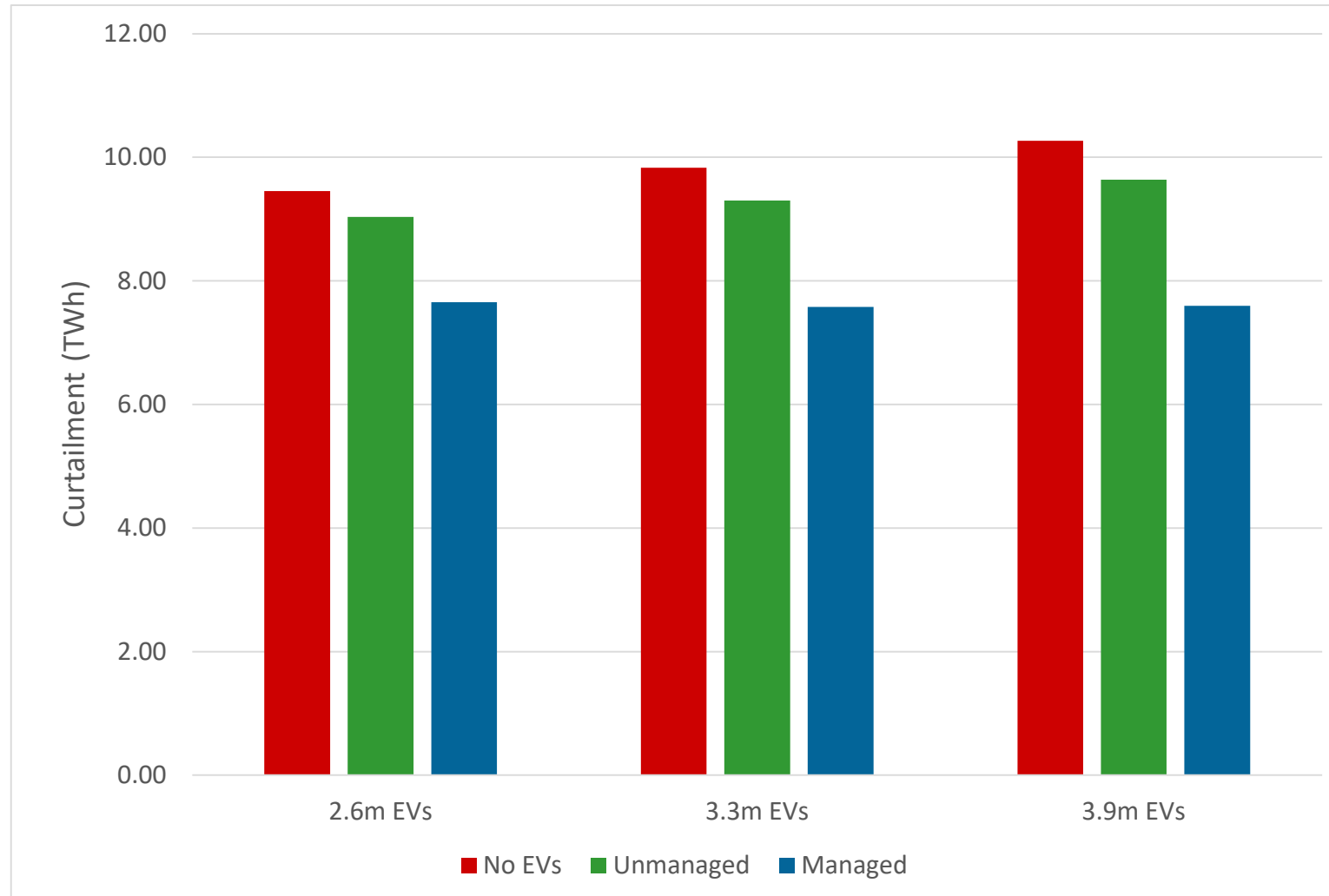
- Understand potential larger grid impacts and benefits, and EV driver and ratepayer \$ return mechanisms
- Flexible load in the form of controlled EV charging can significantly reduce needs for dedicated grid storage as intermittent renewable resources become more highly utilized
- Expand on previous analysis with additional SWITCH and PLEXOS modeling of CA grid and potential EV market penetration for 2020-2030

Task 5 – 2024 California Grid Case



Source: Julia Szinai, UC Berkeley/LBNL, 2017 (CEC EPIC 15-013 project)

Task 5 – 2030 California Grid Case With CPUC Grid Calculator Results



Task 5 – Key Findings

- Flexible load from PEVs can potentially (upper bound) reduce curtailment in California by about 500 GWh in 2024 and 2 TWh in 2030
- This equates to \$10-60 million per year in grid cost savings at alternative wholesale generation costs of \$10-\$30/MWh
- Also indicates potential savings of approximately 72,500 tons (2024) and 290,000 tons (2030) per year of GHG emissions assuming generation with 290 lbs/MWh (avg.) of emissions otherwise needed to charge PEVs

Task 6: Technology/Knowledge Transfer Activities

- Release of open-source code and documentation on “Github”
- XBOS-V project featured in 27 professional presentations by project team members
- Several journal articles published / in preparation
- Follow-up activities planned with TAC members to further project activities and next steps
- Planned Next Step: Larger-scale implementation of XBOS-V at real-world site to demonstrate load control of multiple vehicles

Open-Source Software Code Release

- XBOS platform documentation: <https://docs.xbos.io/>
- XBOS platform code:
<https://github.com/softwaredefinedbuildings/xbos>
- OCPP 2.0 Implementation: <https://github.com/gtfierro/ocpp-2.0>
- Juiceplug driver implementation (XBOS-V):
<https://github.com/SoftwareDefinedBuildings/bw2-contrib/tree/master/driver/juiceplug>
- Aerovironment driver implementation (XBOS-V):
<https://github.com/SoftwareDefinedBuildings/bw2-contrib/tree/master/driver/aerovironment>
- Brick Schema documentation: <http://brickschema.org/>
- Brick database code: <https://github.com/gtfierro/hod>

Question: What Are Near-Term “No Regrets” Concepts for Furthering VGI Progress?

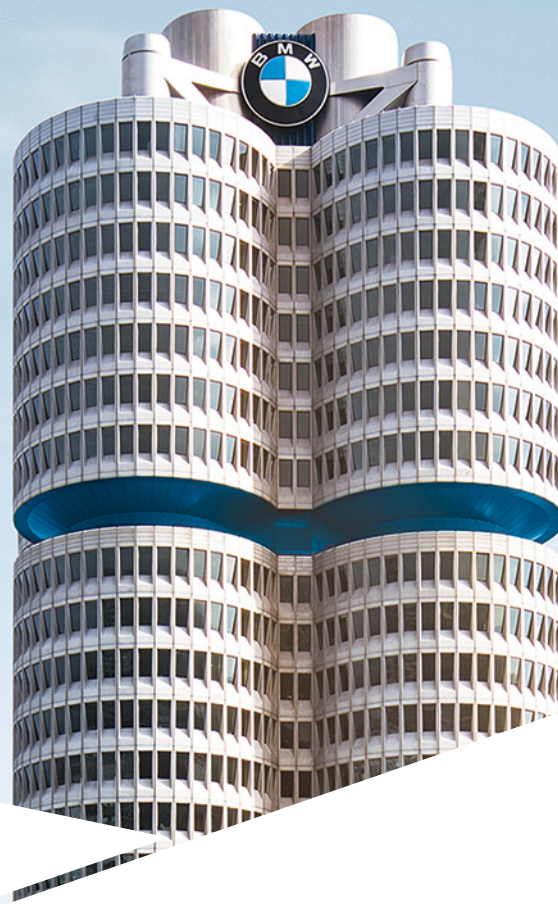
- V1G Smart Charging opportunities based on TOU rates can offer immediate benefits at low cost – key needs are customer awareness and engagement of workplace and fleet settings
- Updated utility “Interconnection Capacity Analysis” maps have information for where next-step V1G and V2G development projects have potential for grid support benefits, along with where there is existing capacity to site DC fast charging
- Communications protocol designs are suggested based on specific use cases, and there are now an emerging set of end-to-end solutions
- Important opportunities to integrate with larger DR and load-shifting efforts – no need to re-invent the wheel for some use cases

BMW CHARGEFORWARD.

EPIC SYMPOSIUM

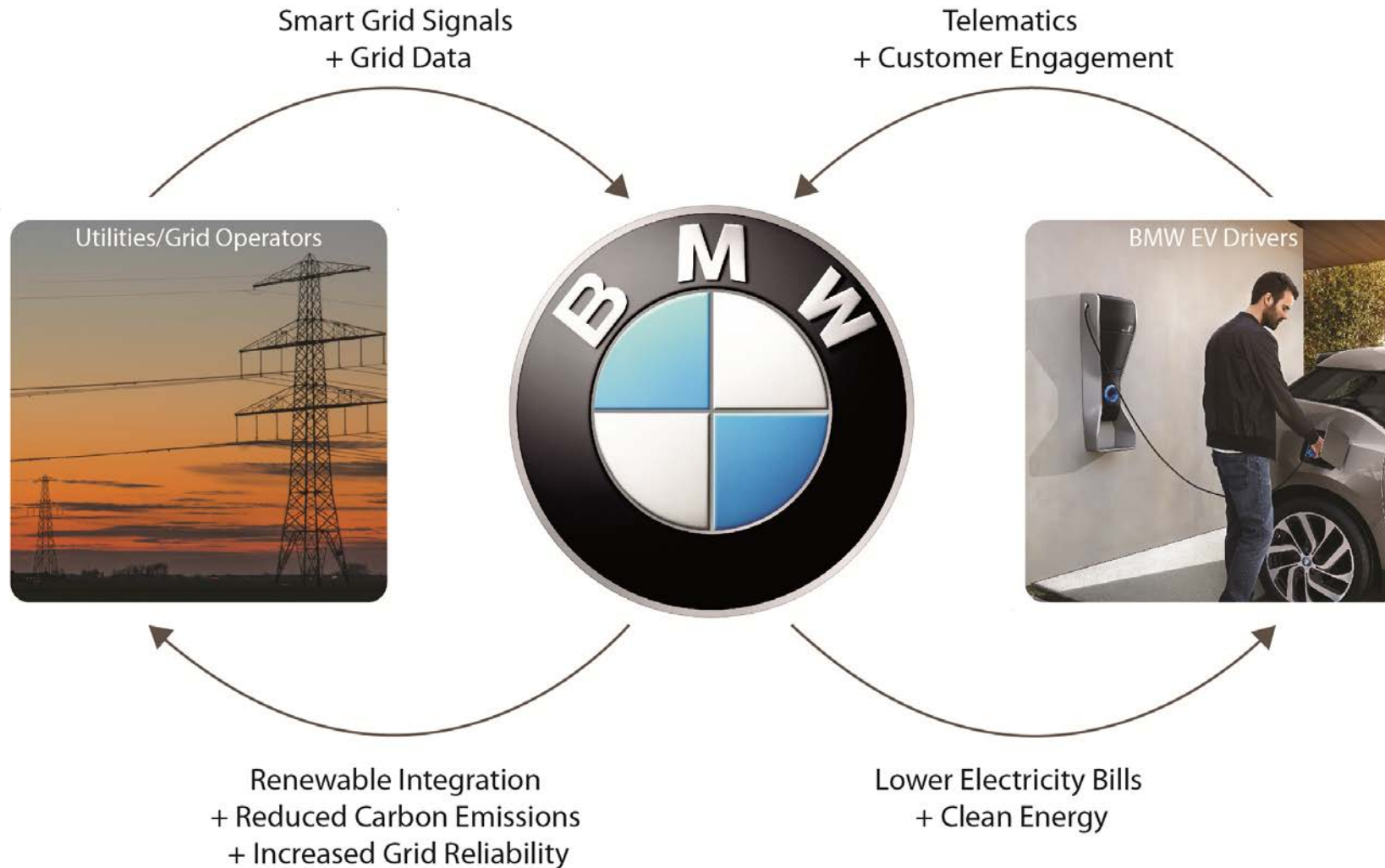
FEBRUARY 19, 2019 SACRAMENTO, CA

Technology Office USA | Feb
2019
Alissa Harrington



BMW SMART CHARGING VISION

BMW envisions a future where electric vehicles help the grid reach **new levels of sustainability**.



VEHICLE TELEMATICS COMMUNICATES SMART CHARGING MESSAGES

The BMW software backend communicates with each participating vehicle using the on-vehicle telematics system...



Grid Signal



...BMW only selects vehicles for participate if they meet a minimum state of charge and the driver is willing to participate...

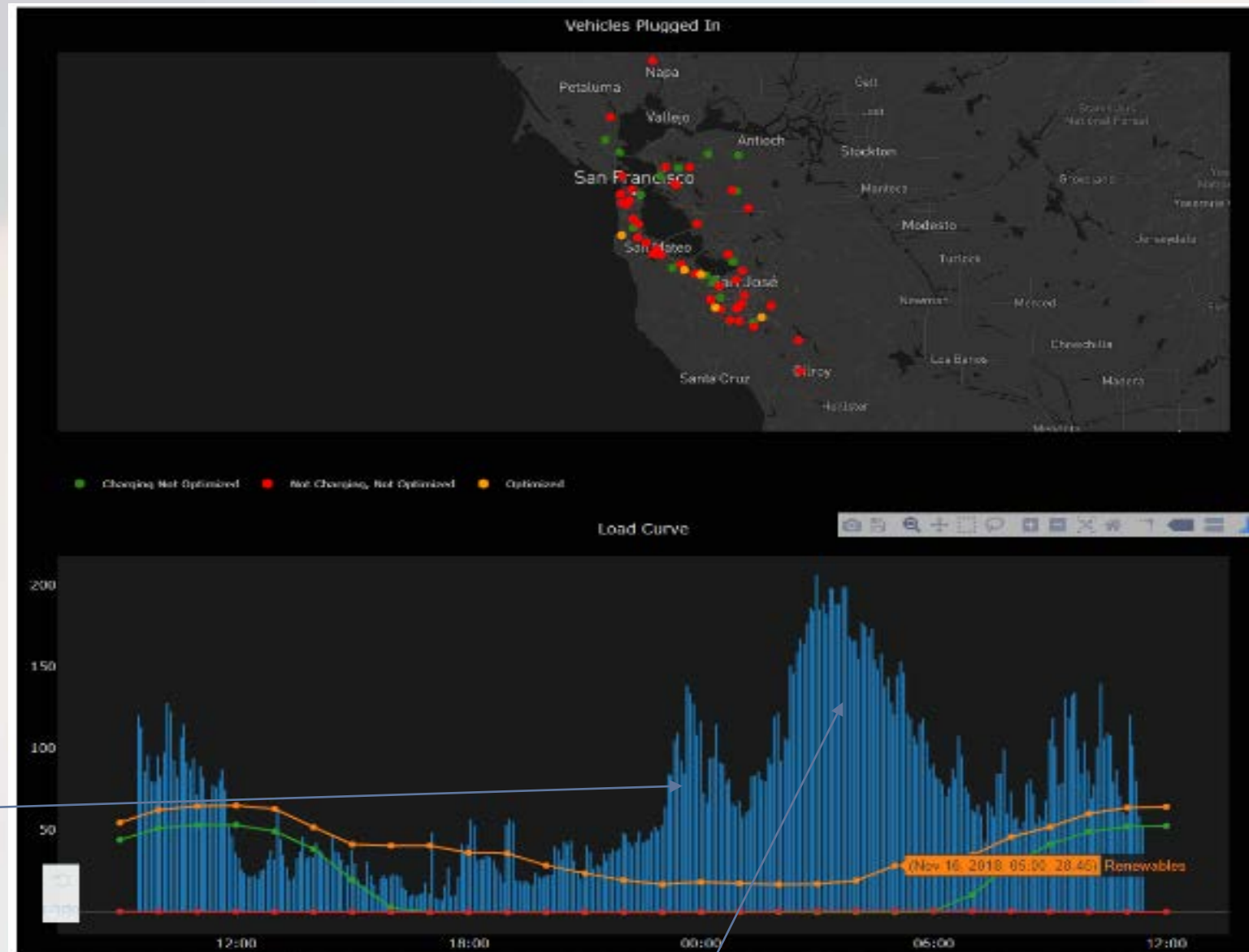
CHARGEFORWARD IMPACT

Smart Charging shifting charging throughout the day and night

Participants charged based on grid signals

- Locational Marginal Price for their location, home or away
- Renewable energy day-ahead estimate
- Overgeneration/Demand response events

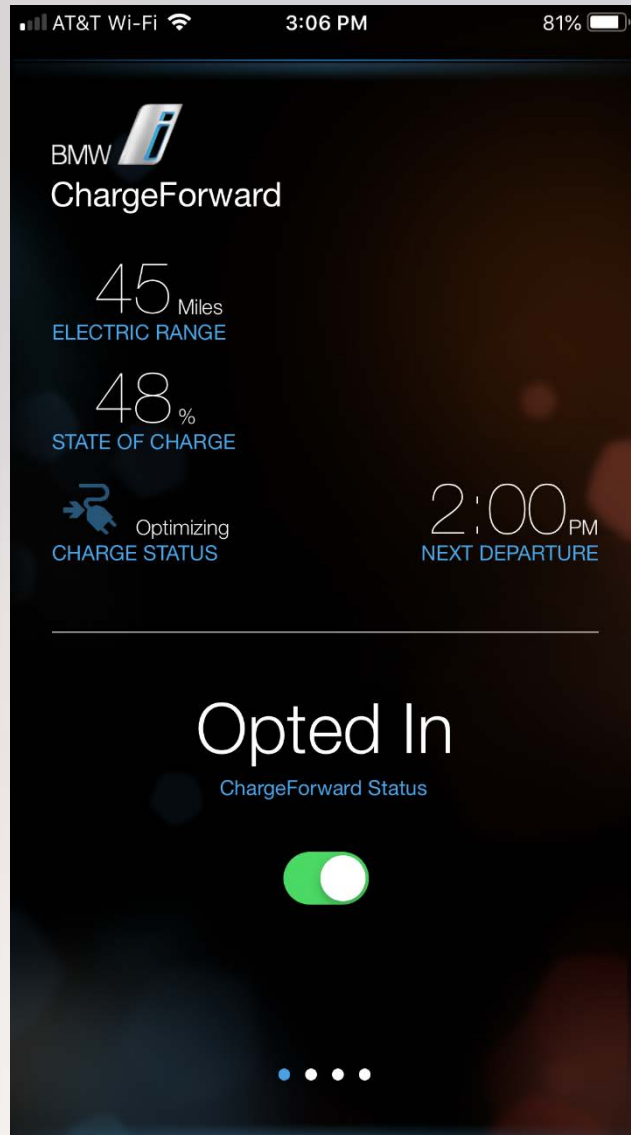
Typical overnight peak for EVs in PG&E territory is at 11 PM. Not all cars are eligible for optimization and still charged at 11 PM.



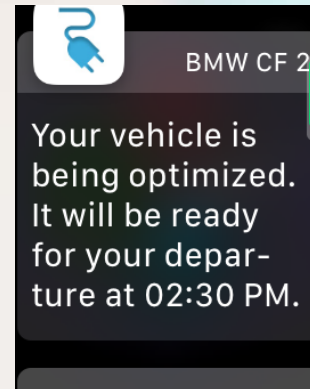
ChargeForward shifts peak to more favorable time

CHARGEFORWARD SMARTPHONE APP

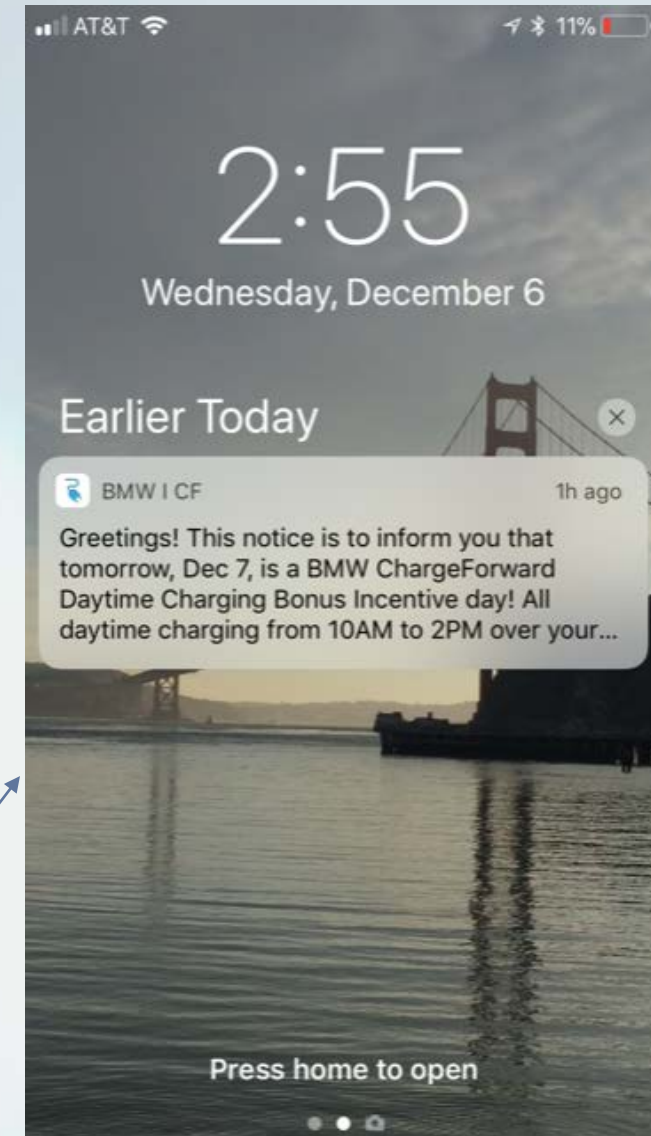
THE CUSTOMER ALWAYS HAS THE RIGHT OF WAY.



'Opt-in/out' feature allows customers to opt-out and start charging whenever they want

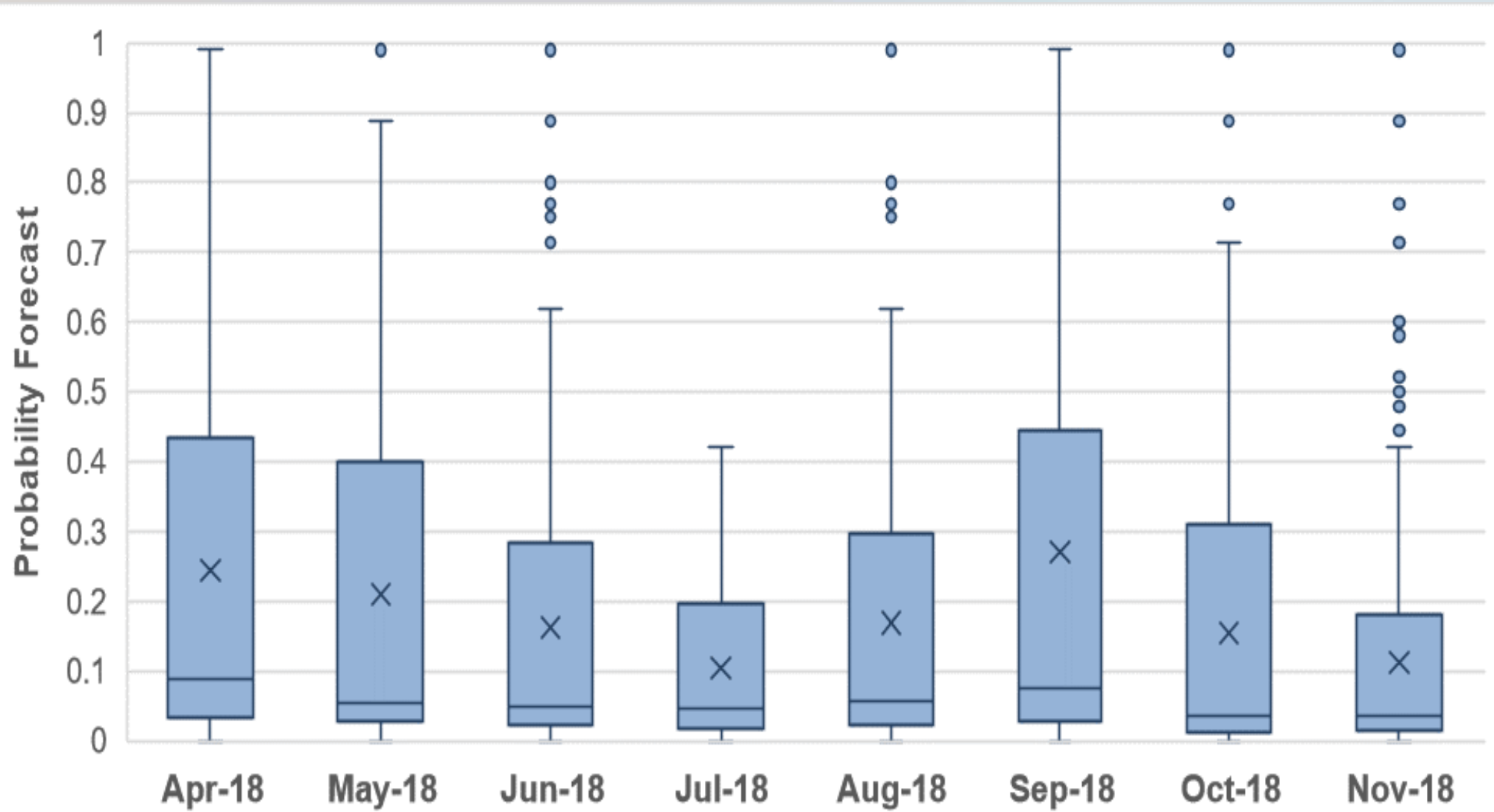


Push Notifications inform a customer when their vehicle is being smart charged and when there is a special event.



CHARGEFORWARD IS WORKING CLOSELY WITH UTILITY AND OTHER PARTNERS TO DEVELOP ADVANCED USE CASES

PG&E PROVIDING OVERGENERATION AND RE FORECAST FOR CHARGE INCREASE EVENTS

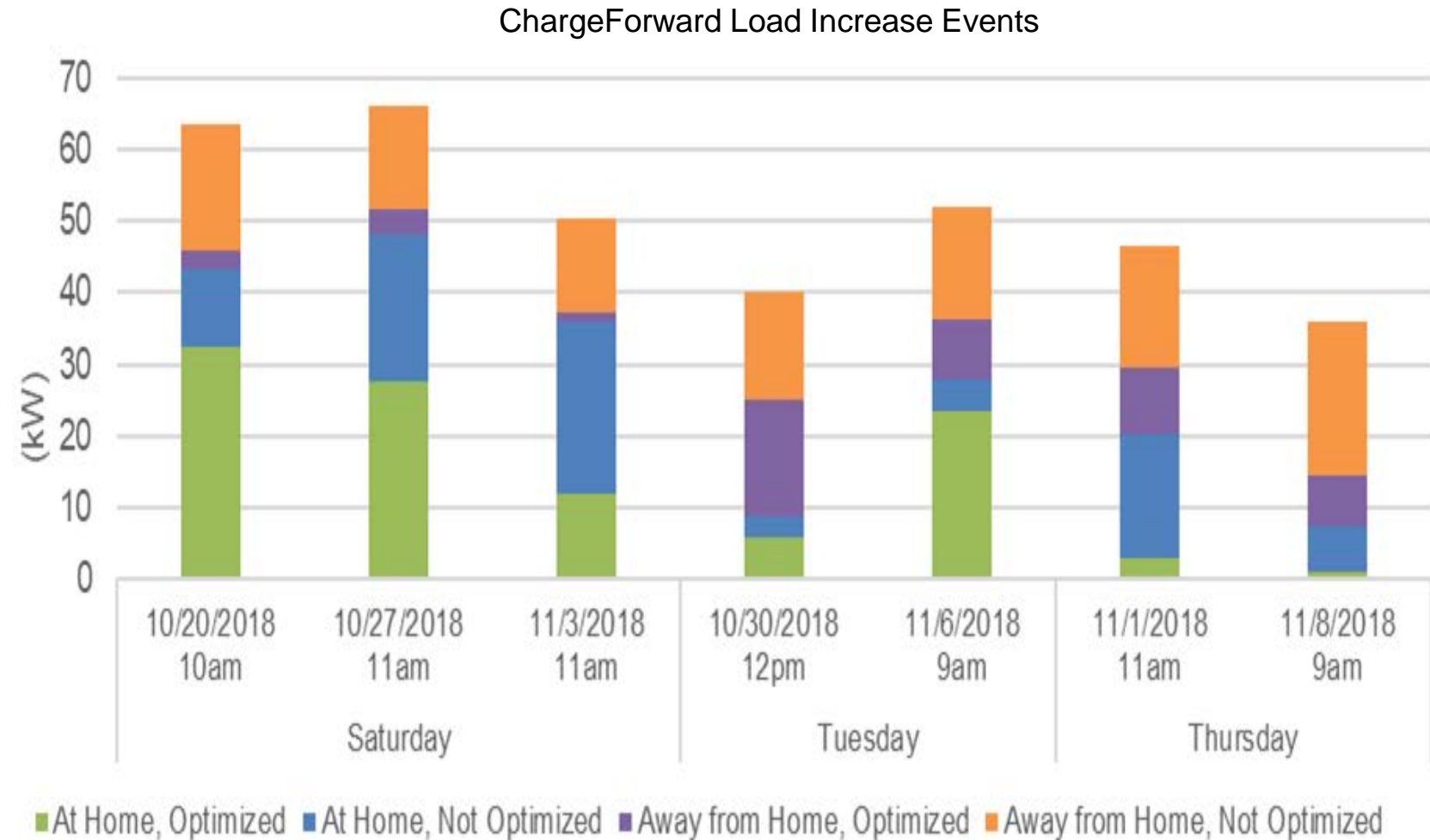


ADVANCED EV USE CASE: OVERGENERATION SIGNALLED LOAD INCREASE EVENTS

Customers Responded to “Increase Charging Events”

-Events called based on PG&E signal

- Participation on weekend days was highest overall, mostly at home
- During the week, most participation occurred away from home
- Participants responded and charged more during the event, with and without optimization



QUESTIONS?



Lunch Session is Currently in Progress

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Efforts to Operationalize Investor Owned Utility EPIC Demonstration Projects

Moderator: **Aaron Renfro**

Presenters: **Mark Esguerra, Simon Han, Christine Asaro**



Networking Break and Poster Session



Investor Owned Utility Coordination of Research Administration Plan & Coordination with EPIC

Moderator: **Dan Gilani**

Presenters: **Dan Gilani, Aaron Renfro, Frank Goodman**



EPIC III Research Administration Plan (RAP)

2019 EPIC Symposium



Agenda

- EPIC Evaluation Background
- Decision 18-10-052 Requirements
- Evaluation Recommendations
- Deep Dive on Specific Recommendations
- Next Steps

EPIC Evaluation Background

- In 2016, the Commission determined in Decision 12-05-037 that an independent evaluation of the EPIC program should be conducted. Commission staff selected Evergreen Economics (Evergreen) to conduct the evaluation; Evergreen distributed its Evaluation on September 8, 2017.
- The overall objective of the evaluation was to “conduct a comprehensive evaluation of EPIC to identify opportunities to improve program management and effectiveness.”
- Based on the results of the evaluation, the Commission found that it is imperative that the IOU administrators develop and implement reasonable process improvements that are responsive to Evergreen’s findings and recommendations.
- Decision 18-10-052 requires the IOUs to prepare and serve a joint application containing a Research Administration Plan (RAP) that identifies the changes they will make to their administrative processes in response to Evergreen’s recommendations.

Decision 18-10-052 Requirements

- The IOUs are required to incorporate the following components into the RAP application:

– Identify improvements that address 12 of the explicit recommendations from Evergreen’s Evaluation
– Consult with CEC and stakeholders when preparing the application
– Host two workshops: 1) pre-development technical workshop; 2) share completed draft application in a second workshop
– Identify any proposals included in the IOUs’ respective EPIC III applications that the IOUs believe should be modified or withdrawn/replaced

- The IOUs are required to file the RAP application by May 1, 2019

Evaluation Recommendations

Program Administration	<ul style="list-style-type: none">• The administrators should provide more detailed justification for non-competitive bidding in their Annual Reports. The current administrative processes do not provide enough information to allow for appropriate oversight.• The CPUC should require the IOUs to specify the funding amount for the noncompetitive award to make it easier to assess the fraction of funding that is being directly awarded. Such information would be useful to determine how much project funding is being directly awarded versus competitively bid.
Portfolio Optimization	<ul style="list-style-type: none">• The administrators should collaborate in categorizing and summarizing projects (such as by technology type and/or policy area) and review projects by topic areas to ensure that the portfolio of projects effectively supports key policy goals.

Evaluation Recommendations (continued)

Stakeholder Engagement	<ul style="list-style-type: none">• The administrators should engage more stakeholders earlier in the investment planning process.• The IOUs should provide more comprehensive information, to allow time for more meaningful engagement.
Administrator Project Selection Process	<ul style="list-style-type: none">• The utilities should develop more transparent project selection criteria, which determine the project areas that are described in their Investment Plans as well as the specific projects that are eventually implemented.• The utilities should share project research plans and budgets with the Commission and the public, at least one month prior to launch.
Match Funding	<ul style="list-style-type: none">• The CEC should consider modifying the match funding requirement for TD&D projects and make it optional.

Evaluation Recommendations (continued)

Benefits Quantification	<ul style="list-style-type: none">• The IOUs should develop more detailed processes to quantify benefits associated with their projects.
Results Dissemination	<ul style="list-style-type: none">• SCE should share its project results more widely with interested stakeholders, including delivering presentations at conferences and workshops.
Project Impacts & Policy Alignment	<ul style="list-style-type: none">• EPIC administrators should establish a process to ensure that once Applied R&D projects are completed by the CEC, administrators consider the results and identify potential TD&D projects.
On-Going Program Evaluation	<ul style="list-style-type: none">• The administrators should create a single, centralized database containing all relevant information on active and completed EPIC projects along with monitoring and quarterly reporting of key performance metrics, in order to support the on-going evaluation of the Program.

Deep Dive - Portfolio Optimization

“The administrators should collaborate in categorizing and summarizing projects (such as by technology type and/or policy area) and review projects by topic areas to ensure that the portfolio of projects effectively supports key policy goals.”

Discussion Topics:

- Current non-duplication matrix is a good start, but opportunity to enhance
- Possible ideas on how to add to the existing non-duplication matrix:
 - Categorize/summarize projects by technology type and policy area
 - Ensure all relevant Federal and CA Legislation is included
- Example: Expediting innovation in transportation electrification

Deep Dive - Stakeholder Engagement

“The administrators should engage more stakeholders earlier in the investment planning process; and The IOUs should provide more comprehensive information, to allow time for more meaningful engagement.”

Discussion Topics:

- Conduct a stakeholder outreach session before each subsequent “wave” of EPIC projects is launched
- Conduct more frequent stakeholder outreach sessions
- Conduct more meetings with DACs
- Conduct more community outreach for EPIC projects that have field demonstration components
- Generate more engagement through IOUs’ EPIC websites

Deep Dive - Benefits Quantification

"The IOUs should develop more detailed processes to quantify benefits associated with their projects"

Discussion Topics:

- Convey benefits, including DAC benefits, in project closeout report
- Provide updates on realized benefits in subsequent annual reports
- Stop providing updates on benefits in annual reports if/when the project is transitioned to the GRC (since benefits are covered in GRC workpapers)

Next Steps

- 3/15/19: Incorporate workshop feedback into RAP application
- 4/1/19: Conduct second workshop at SCE
- 5/1/19: IOUs jointly file RAP application